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Abstract

CONTROL-ROD MATERIALS

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In the papers on control-rod materials given at the 1958 Conference on the Peaceful Uses of Atomic Energy, the development of specific materials for specific applications was described, but the performance of materials in power reactors was not discussed. Since then, many control-rod materials have received thorough testing in power-reactor applications. Also, since 1958, the U. S. Atomic Energy Commission has sponsored a comprehensive program to provide data and develop technology on control-rod materials. Consequently, much information has been published since 1958 on control rod materials and their performance, and one book on the subject has become available.

The progress of control-rod materials technology in the United States is discussed; power reactor applications are emphasized. The materials discussed in some detail are: boron in alloys as compounds and in dispersions; hafnium in elemental form; the lanthanons as oxides, compounds, alloys, and dispersions; and the silver/indium/cadmium alloy.

Progress in fabricating boron-containing materials is discussed. Neutron irradiation effects and the extent of helium release are presented for boron-containing materials as related to boron burnup and crystal structure. Experience with boron in various forms is described for Dresden, the Vallecitos Boiling Water, Elk River, N. S. Savannah, Big Rock Point, Hombolt Bay, and SM-1 reactors. The low cost, simplicity of fabrication, and the excellent performance of vibratory-compacted boron carbide in tubes is discussed.

The use of hafnium, formerly confined to naval reactors, has been extended to commercial power reactors, Shippingport, Indian Point, second core of Yankee, and some blades in the Experimental Boiling Water Reactor. Hafnium availability

for commercial reactors is improved. Information on the performance of hafnium is still meager, but evidently hafnium has performed well.

The data on the lanthanons as alloys, oxides, and compounds are reviewed and their use in dispersions is described. The use of mixed gadolinium and samarium oxide in the Hallam reactor is discussed. A discussion of the fabrication problems in using europium oxide as a dispersion in stainless steel for the SM-1 and SM-1a reactors is given. Europium oxide has been utilized as a high-temperature control material for the HTRE by containing it in segmented nichrome cans. When used as a dispersion in stainless steel for the PM-1 reactor, europium oxide is formulated with titania to obtain the desired corrosion resistance. Newer compounds of the rare earths, such as the tungstates, are also discussed.

Control rods of nickel-plated, silver/indium/cadmium alloy were used originally in the Yankee reactor. During refueling of Yankee, dissolution of the alloy occurred where the nickel plating had worn, with subsequent deposition of radioactive silver on all reactor surfaces. The silver indium cadmium rods in Yankee were replaced with hafnium. Silver indium cadmium may still be used as the control material in the third core of Yankee, but clad with Inconel. The alloy also is in the Saxton experimental pressurized water reactor operating at 280C.

An economic evaluation of control materials is given in which the costs of materials and fabrication are balanced against lifetimes estimated from nuclear-worth depreciation.